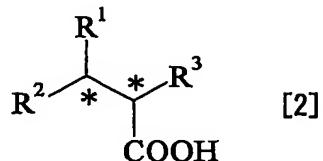
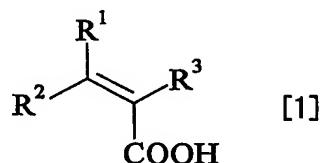


claim

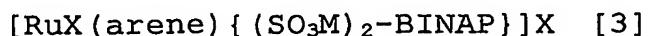
1. A method for producing an optically active carboxylic acid represented by the formula [2]:



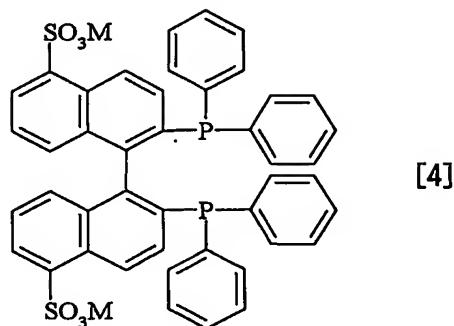
wherein R¹, R² and R³ independently represent a hydrogen atom, an alkyl group, an alkenyl group or an aryl group, the groups may have a substituent, R¹, R² and R³ is not a hydrogen atom simultaneously, R³ is a group other than a hydrogen atom when one of R¹ and R² is a hydrogen atom, R³ is a group other than a hydrogen atom and a methyl group when both of R¹ and R² are hydrogen atoms, and R¹ and R² are different groups other than a hydrogen atom when R³ is a hydrogen atom, and at least one of the two carbon atoms marked with * represents an asymmetric carbon atom, comprising the step of subjecting an α,β-unsaturated carboxylic acid represented by the formula [1]:



wherein R¹ to R³ have the same meanings as those in the formula [2], in the presence of a sulfonated BINAP-Ru complex represented by the formula [3]:



wherein $(SO_3M)_2$ -BINAP represents a tertiary phosphine represented by the formula [4]:



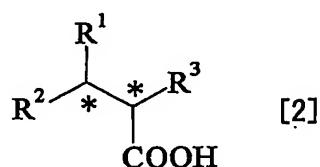
M represents an alkaline metal atom, X represents a chlorine atom, a bromine atom or an iodine atom, and arene represents a benzene or an alkyl-substituted benzene, in an aqueous solvent, to an asymmetric hydrogenation.

2. The method according to claim 1, wherein the aqueous solvent is water or a mixed solvent of water and a water-insoluble organic solvent.

3. The method according to claim 1, wherein the sulfonated BINAP-Ru complex is recovered.

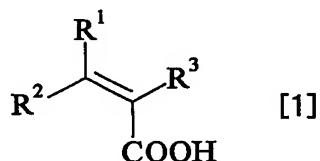
4. The method according to claim 1, wherein the sulfonated BINAP-Ru complex is recycled.

5. A method for producing an optically active carboxylic acid represented by the formula [2]:



wherein R¹, R² and R³ independently represent a hydrogen atom,

an alkyl group, an alkenyl group or an aryl group, the groups may have a substituent, R¹, R² and R³ is not a hydrogen atom simultaneously, R³ is a group other than a hydrogen atom when one of R¹ and R² is a hydrogen atom, R³ is a group other than a hydrogen atom and a methyl group when both of R¹ and R² are hydrogen atoms, and R¹ and R² are different groups other than a hydrogen atom when R³ is a hydrogen atom, and at least one of the two carbon atoms marked with * represents an asymmetric carbon atom, comprising the step of subjecting an α,β-unsaturated carboxylic acid represented by the formula [1]:



wherein R¹ to R³ have the same meanings as those described above, in the presence of a recovered sulfonated BINAP-Ru complex used in the method according to claim 1 in water or a mixed solvent of water and a water-insoluble organic solvent to an asymmetric hydrogenation.

6. The method according to claim 5, wherein the α,β-unsaturated carboxylic acid is hydrogenated in the presence of an aqueous solution containing the sulfonated BINAP-Ru complex, and the aqueous solution is obtained by separating a water phase from the reaction mixture after the asymmetric hydrogenation in the method according to claim 1.